Real-time Seafloor Monitoring System for Earthquake and Tsunami (DONET) in Southwestern Japan

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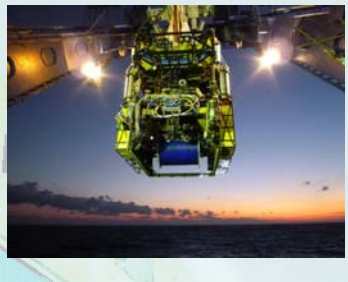
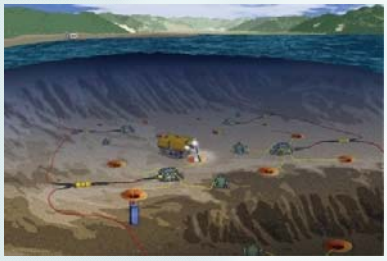
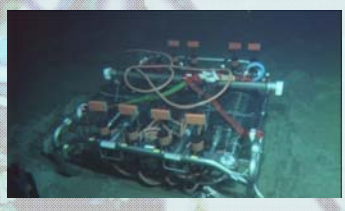
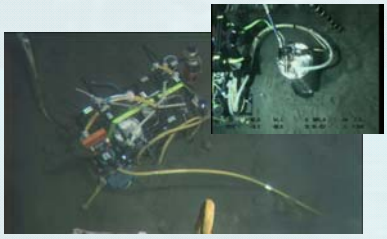
JAPAN AGENCY FOR MARINE-EARTH SCIENCE AND TECHNOLOGY



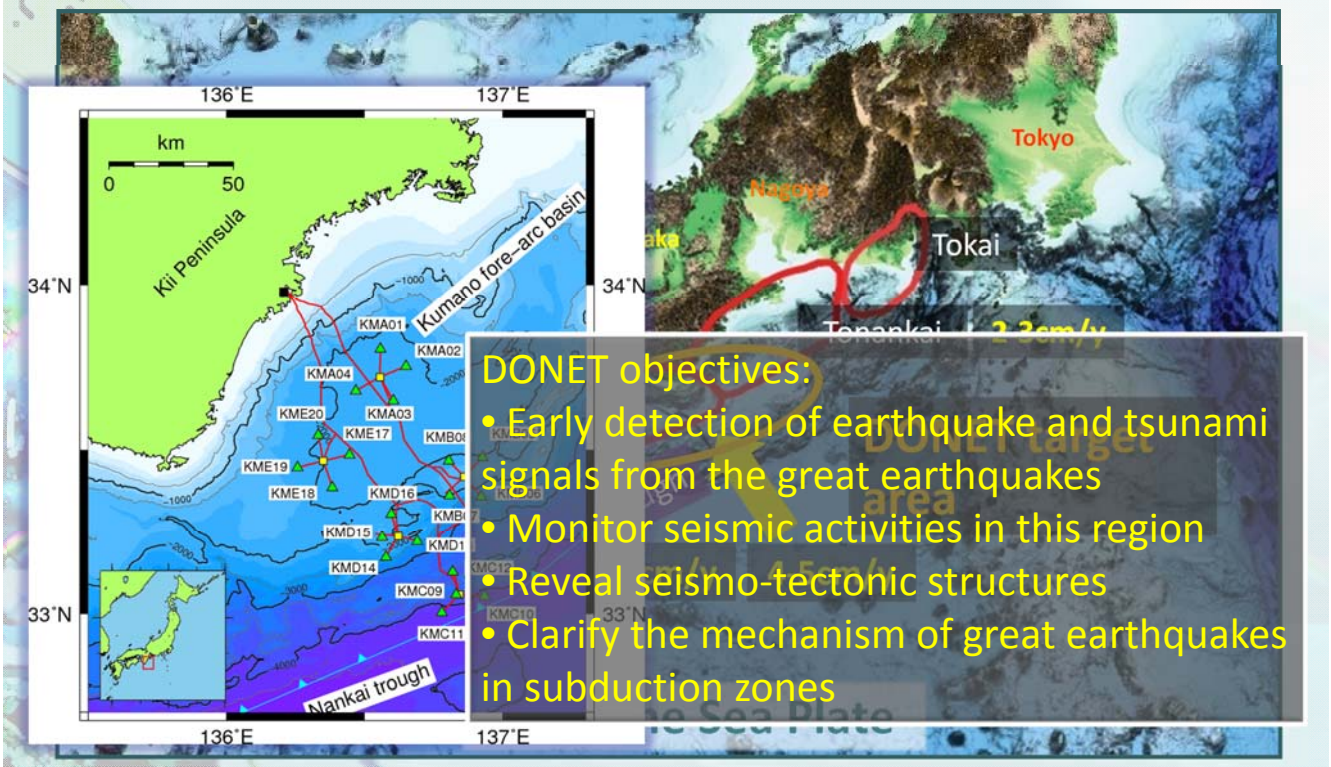


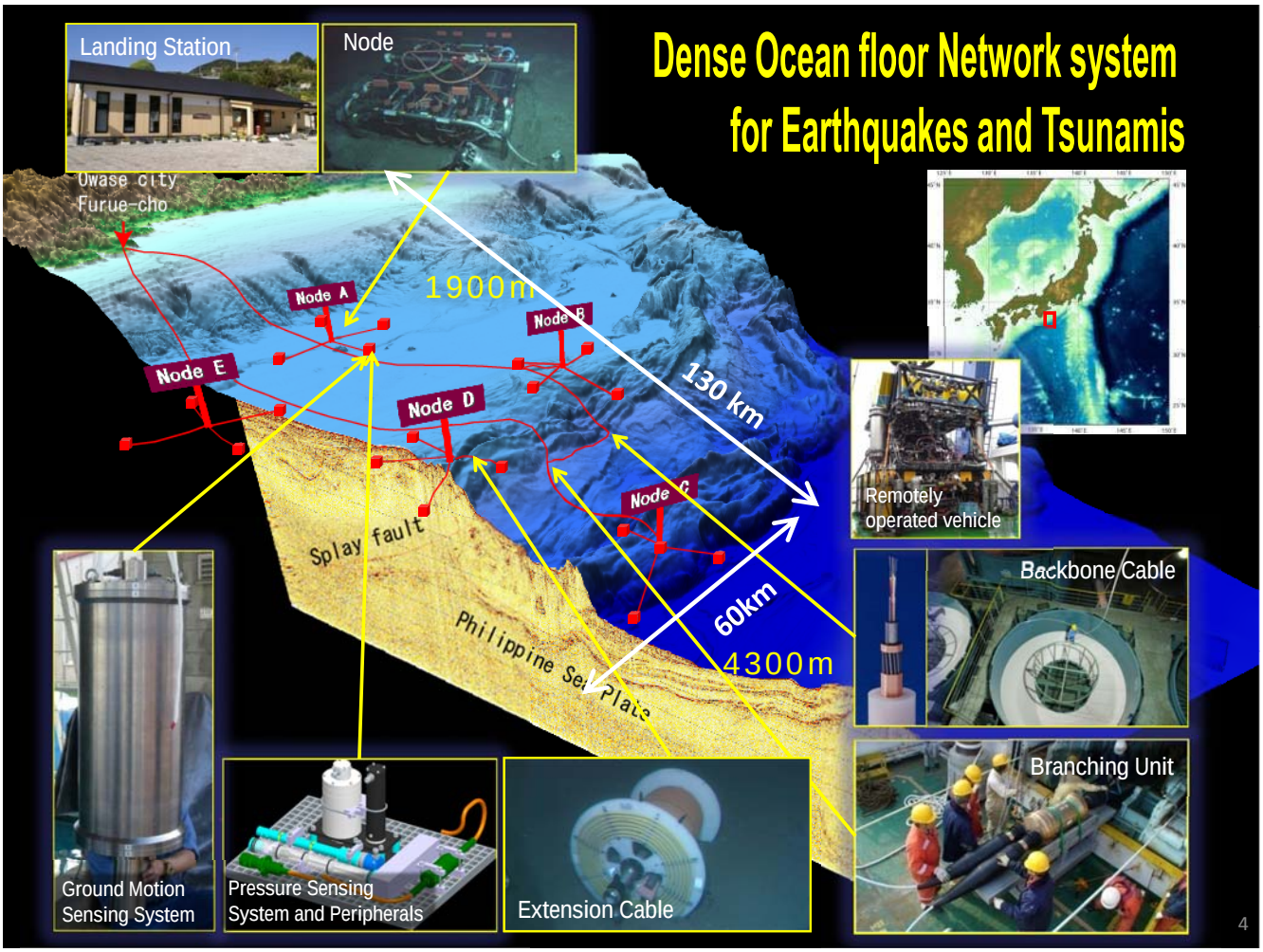
DONET stands for DENSE OCEANFLOOR NETWORK SYSTEM FOR EARTHQUAKE AND TSUNAMI





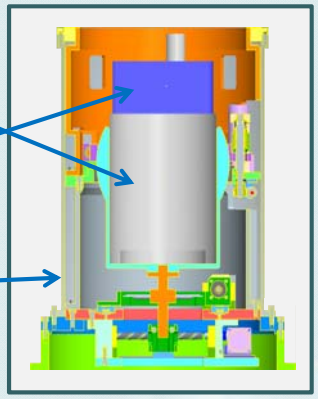
DONET Observation Area



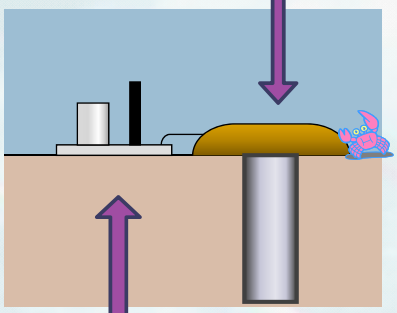


DONET sensors

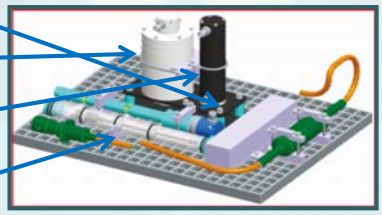
Seismometer package
- Broad-band seismometer
  - High-sensitivity
  - 0.02 — 360 s
- Strong-motion seismometer
  - up to ±4G
  - DC — 225Hz
- Gimbals mechanism



Buried below ocean-floor



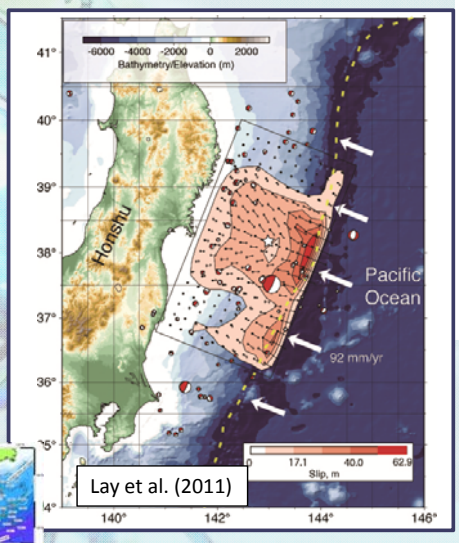
Pressure gauge package
- Hydrophone
  - 2Hz — 30kHz
- Differential pressure gauge
  - 0.1 – 100 s
- Quartz pressure gauge
  - Absolute pressure
- Precise thermometer



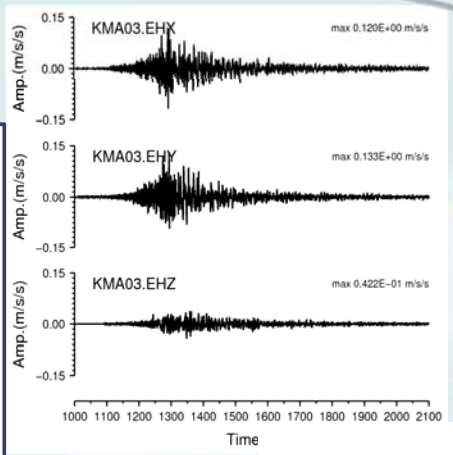
Various signals observed by DONET

The 2011 Tohoku-Oki earthquake

Slip of the 2011 Tohoku earthquake

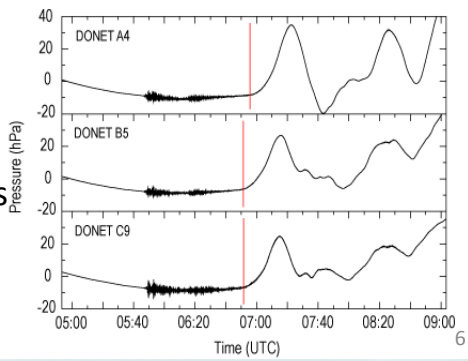


DONET



Strong-motion seismic records (more than 0.1 m/s^2)

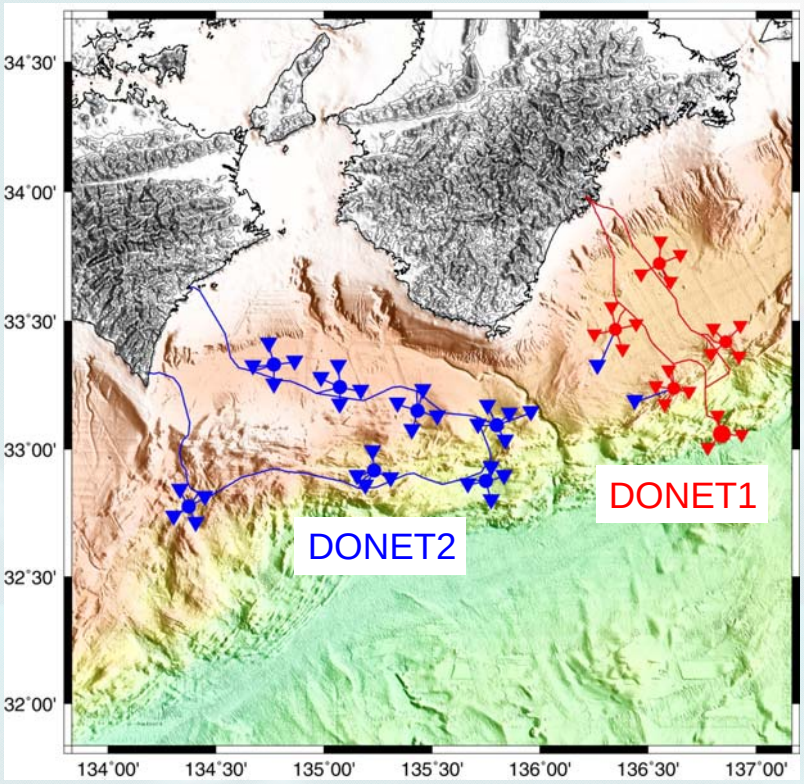
Tsunami signals observed by pressure gauges (~40 cm high)



New Real-time Monitoring System in the Nankai Trough (DONET2)

DONET2 fact sheet
(in ( ) is DONET1)

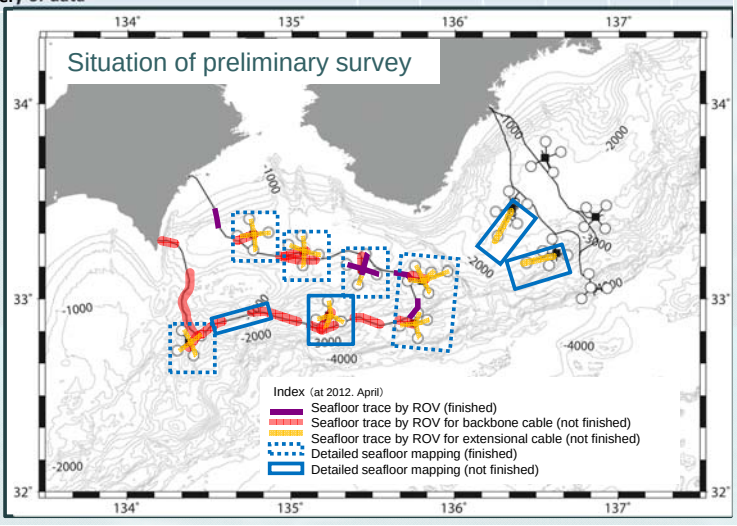
Backbone cable length:
~350km (~250km)
Number of Branching Unit: 7 (5)
Number of Node: 7 (5)
Number of Observation system:
29 (20+2)
Total Budget: 114 million US$
(64 million US$)



DONET2: Development Schedule

Development item	Contents	2010	2011	2012	2013	2014	2015
To high voltage	Sophistication of the system corresponds to larger number of observation points and longer cable length	←	—	→			
Construction of Backbone Cable system, Observational equipment ,etc	Backbone cable, Branching Unit, Node, Ground Motion Sensing System, Pressure sensing system, etc	←	—	—	→		
Deploying the Backbone cable					↔		
Preliminary survey, Installation of the Observational equipment	Survey of sea-bottom situation in the deployment area and installation			←	—	—	→
Operation of the system	Maintenance of the system, Management and delivery of data					←	—

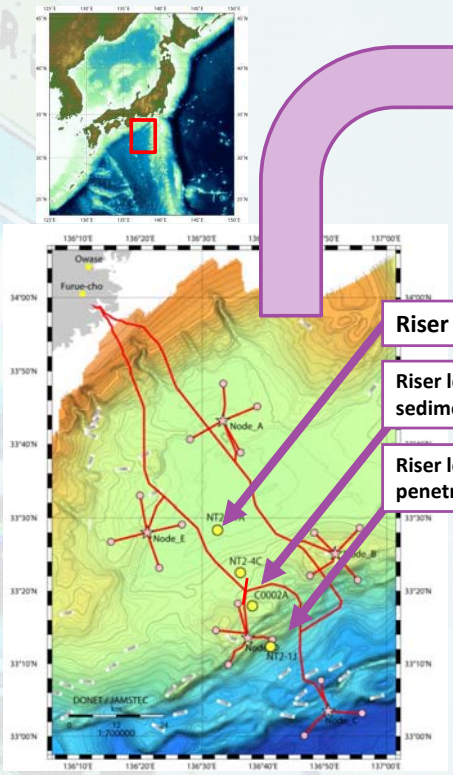
※DONET2 will be finished deploying by the end of Japanese fiscal year of 2015. We are now assembling sensing systems and making seafloor cables. Site survey are also being conducted to finalize the cable route and sensor locations.



Data Transfer System

DONET data will be open to the public

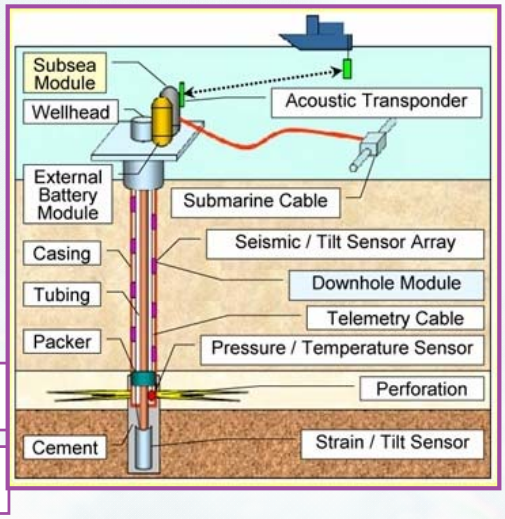
Connection of Borehole Observatories



Riser ~ 2.5km hole

Riser less ~ 1km hole below sediment layer.

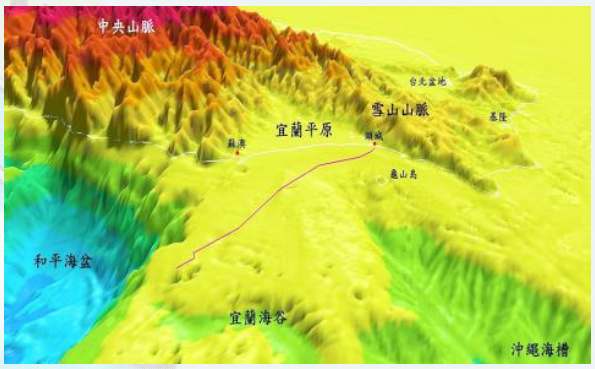
Riser less ~ 500m hole penetrating shallow splay fault



Location of the borehole observatories are planned within the reach (10km or 20km) of DONET.

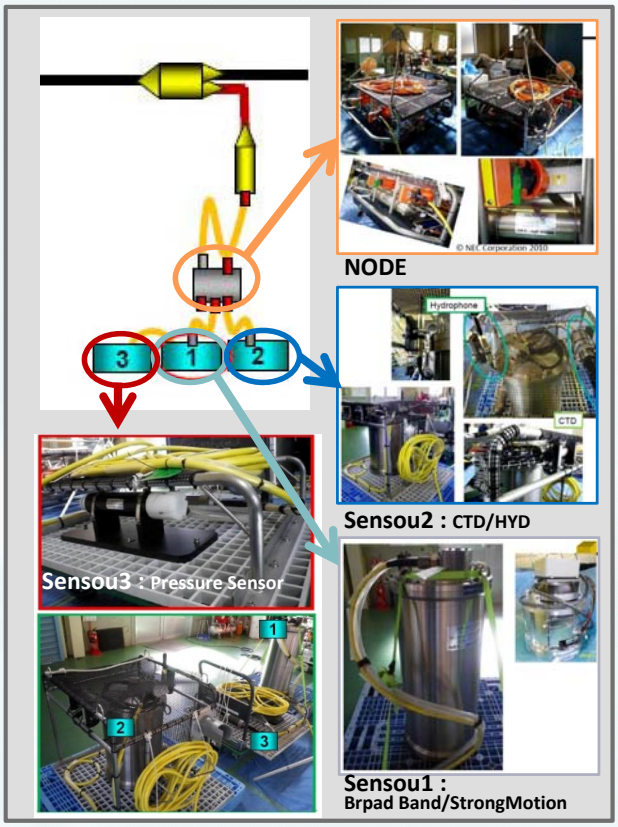
One of the borehole observatories will be connected to DONET in January, 2013 to carry out long-term monitoring.

MACHO (Marine Cable Hosted Observatory) by Central Weather Bureau Taiwan



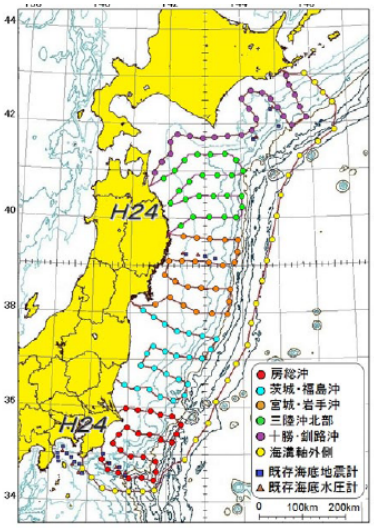
At present the project to build three-dimensional progress of the first phase of the project roadmap

Macho adopted the same configuration of DONET to start in 2011. The cable length is 45 km. The number of the relevant nodes and the monitoring instruments are 1 set. Instrument and construction cost (total cost) is about 16 million US$.



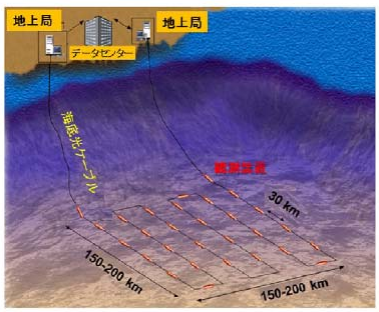
The Tohoku Cable System operated by NIED

Tohoku Array



154 observation points in total
Each consists of seismometer and pressure gauge
6 Looped cables

Schematic figure of the system



In-lined cable observatory

- Up to 8000m of water depths
- Seismometer and pressure gauges

Large-scale seafloor observatory for earthquake and tsunami in the area of the 2011 Tohoku earthquake

- Continuous data collection in real-time over the wide area
- Reveal mechanism the subdcution zone earthquake
- Rapid earthquake tsunami detection

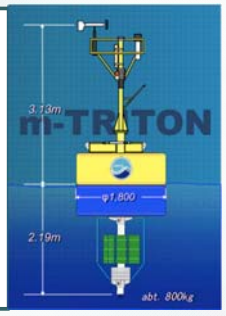
NIED

Newly Developing System

Development of new offshore buoy system for bottom pressure observation using m-TRITON buoy

Real-time observation specialized for tsunami
Mooring system resisting the strong ocean current (~ 5 kt.)
Satellite communication
Installation (relatively) quickly over the ocean

- Doubled iridium communication
- Tsunami measurement by single GPS observation at the sea surface
- Sampling rate of 10 seconds.



1000m-length wire with multiple cable cores

Transducer below the wire

Polypropylene rope ϕ19

Nylon rope ϕ17

Utilization of slack mooring
Slack ratio: about 1.3

45°

Bottom pressure data

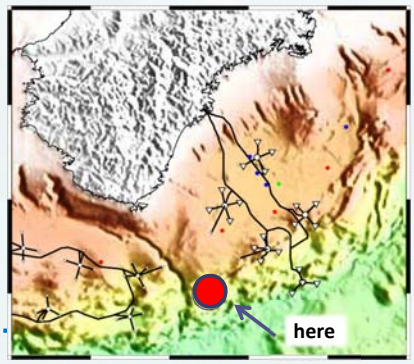
Releaser

Anchor
3.7～4t

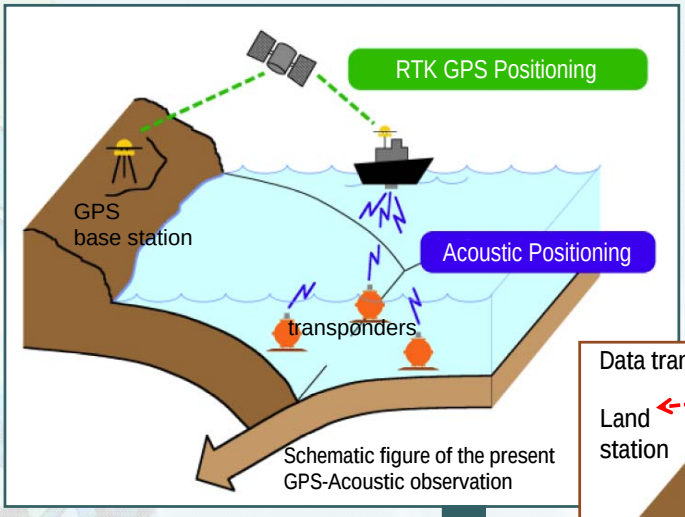
Bottom unit（beam directivity ±45°）

Ocean-bottom pressure gauge

Potential observational area off Kii Pen



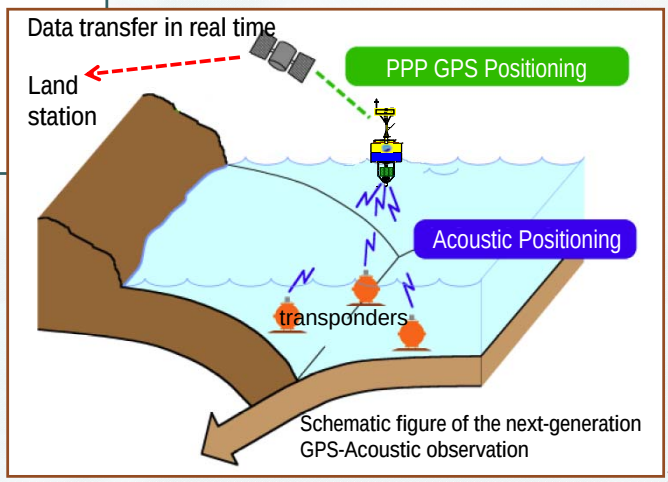
Further application to GPS-Acoustic observation for the seafloor crustal displacement



Schematic figure of the present GPS-Acoustic observation

Seafloor deformation observation is important to understand crustal stress accumulation leading the future subduction zone earthquake.

In the GPS-Acoustic method, the ship location is measured by Kinematic GPS at first. And then, the location of seafloor transponders are determined by acoustic positioning from the ship.

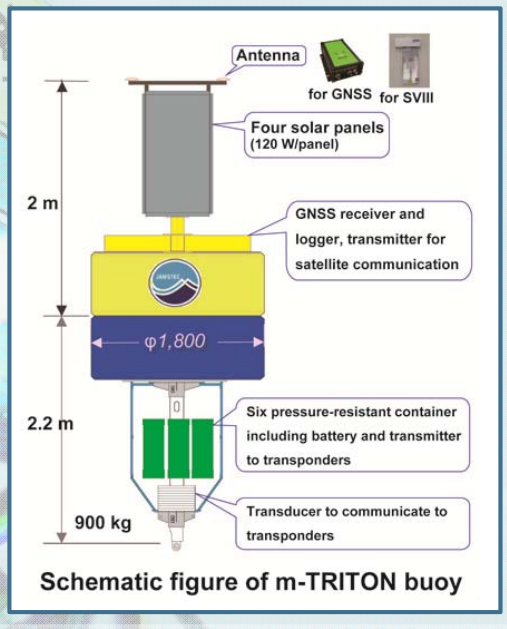


Schematic figure of the next-generation GPS-Acoustic observation

It is good method, but not in real-time, not continuous data collected.

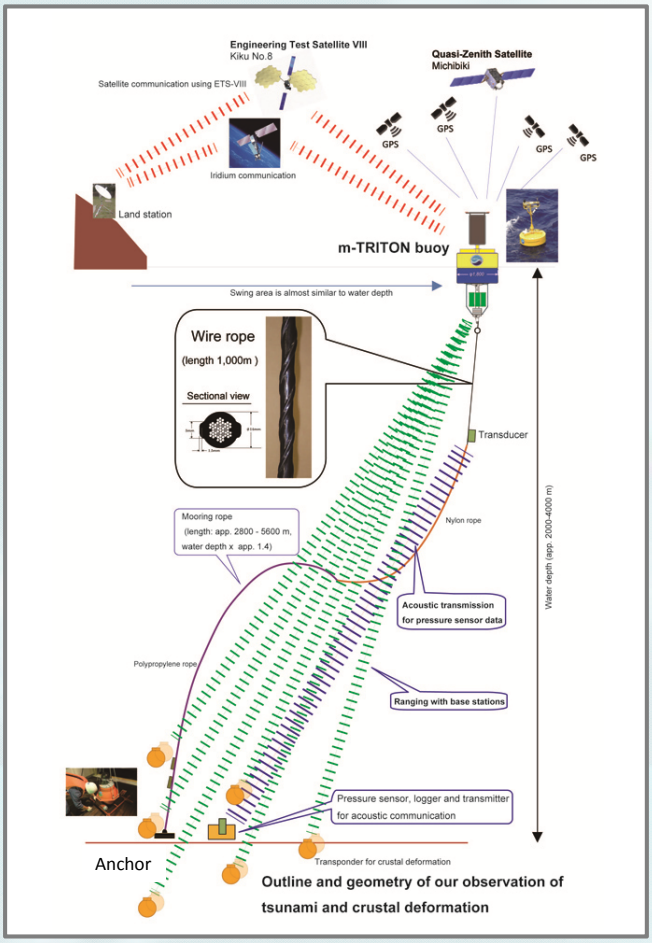
Use of the buoy instead of the survey ship enable to the real-time, continuous observation of the seafloor deformation.

Final design of the new buoy system



Schematic figure of m-TRITON buoy

Two observation, bottom pressure observation and GPS Acoustic observation will be combined on the buoy system. The buoy location is determined by Precise Point Positioning method. The buoy determines the position of the seafloor transponders using acoustic positioning. Bottom pressure simultaneously is observed. data is sent to the buoy. A system test will be conducted in the ocean next year



Outline and geometry of our observation of tsunami and crustal deformation

Real time observation for tsunami and crustal deformation using m-TRITON buoy

1. Buoy
- (1) Strong sea current environment with high speed of over 5 knots.
- (2) Target water depth is from 2000m to 4000m.

2. Tsunami
- (1) Pressure data with 10 sec sampling in tsunami mode
- (2) Normal mode is 1 minute interval

3. Crustal deformation
- (1) Once a week interval
- (2) Six transponders at sea bottom

4. Precise Point positioning (PPP) on sea surface
- (1) Real time measurement using LEX signals
- (2) Resolution of 10 cm

5. Real time transmission to land stations
- (1) Iridium transmission
- (2) ETS-VIII transmission for next generation development of satellite communication

6. Development budget of about 1 million US$ per 1 set

Summary

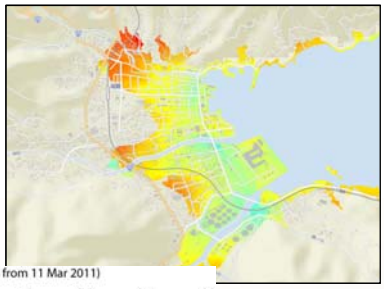
- DONET is a seafloor cabled observatory in the Nankai Trough equipped with broad-band seismometer, strong-motion seismometer, hydrophone, differential pressure gauge, quartz pressure gauge, precise thermometers.
- DONET provides real-time monitoring of earthquake, tsunami and crustal displacement under the sea resulting in improvements of earthquake and tsunami early warnings and understanding the subduction zone earthquake.
- DONET1 has been under full operation since 2011, and the data will be open to the public soon.
- DONET technology was exported to TAIWAN system (MACHO).
- DONET2 will be deployed in the neighboring area to the west of DONET1 by the end of Japanese fiscal year of 2015.
- A new buoy system equipped with ocean-bottom pressure gauges and instruments for GPS-Acoustic measurement is investigated. A system test will be carried out in the ocean the next year.

Thank you for your attention

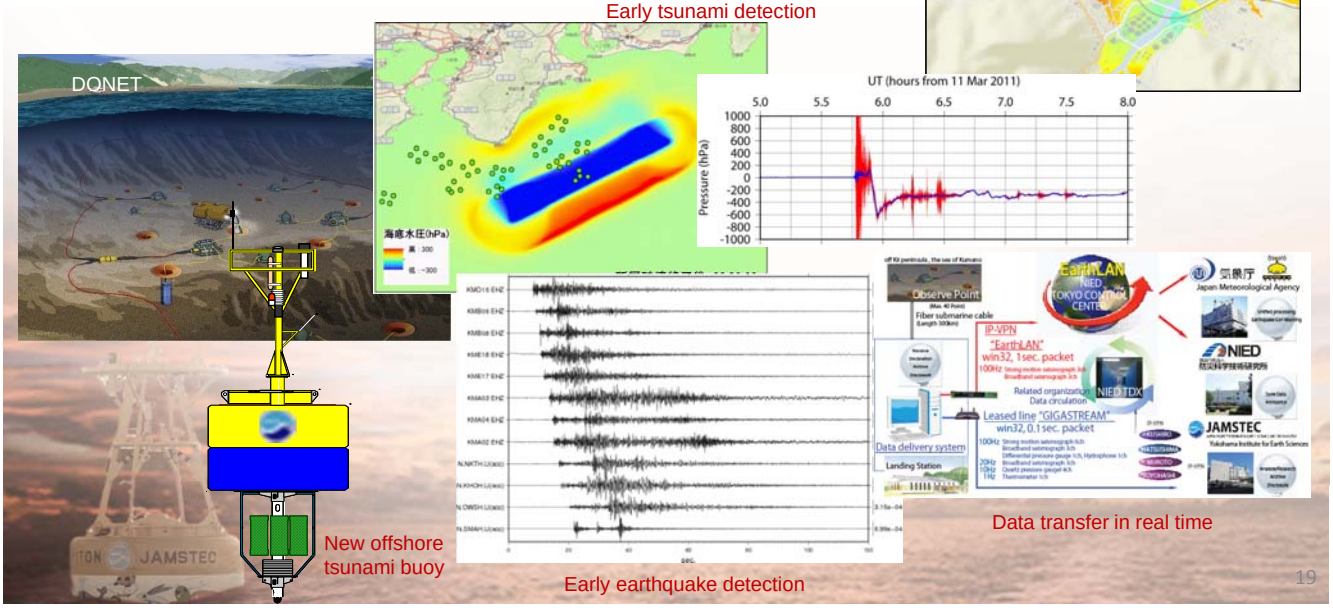
Our marine technology contributes to mitigate earthquake and tsunami disaster

Early detection and precise alert of seismic intensity and tsunami are helpful saving lives and decreasing damages

Early tsunami prediction



Early tsunami detection



New offshore tsunami buoy

Early earthquake detection

Data transfer in real time